

# REMARKS

Although this PCT application was amended in the International Phase, instead of translating those amended claims, Applicant is submitting amended claims 1-19 and adding claims 20-21. All multiple dependencies have been eliminated. Further, improper references, in the specification, to the content of the claims, have been replaced by paraphrases of those claims. If the examiner notes any remaining informalities which would delay examination on the merits, a call to Applicant's counsel is solicited.

A check for the filing fee is enclosed; no additional fee is believed required; if any is required, it may be charged to Deposit Account No. 23-0442.

Respectfully submitted,

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## MINIATURE FAN OR MICRO-FAN

This application is a section 371 of PCT/EP02/13822, filed  
6 DEC. 2002 and published 17 JUL. 2003 as WO 03-058 796-A1.

FIELD OF THE INVENTION:

The invention ~~refers~~ relates to a miniature fan or  
5 micro-fan that is driven by an electronically commutated  
external-rotor motor.

BACKGROUND:

Miniature fans or micro-fans serve, for example, to cool  
processors in computer, to cool small devices, etc., and they  
10 have very small dimensions. For example:

fans of PAPST series 250 have dimensions of 8 x 25 x 25 mm,  
those of PAPST series 400F, dimensions of 10 x 40 x 40 mm,  
those of PAPST series 400, 20 x 40 x 40 mm,  
those of PAPST series 500, 50 x 50 x 15 mm, and  
15 those of PAPST series 600, 60 x 60 x 25 mm.

The power consumption of such fans is 0.4-0.6 W for  
series 250, 0.7-0.9 W for series 400F, 0.9-1.6 W for series  
400, and 0.8-3.4 W for series 600. This defines the preferred  
field of application of the present invention.

20 In fans that are driven by an electronically commutated  
external-rotor motor, the motor is large in relation to the  
overall size of the fan, which is disadvantageous in terms of  
the flow rate (V/t) and pressure increase  $\Delta p$  of the fan.

SUMMARY OF THE INVENTION:

25 It is therefore an object of the invention to make  
available a new miniature fan or micro-fan.

According to the invention, this object is achieved  
~~by the subject matter of Claim 1. by arranging a rotor~~  
position sensor centrally but other control components outside  
30 the air duct. It is thereby possible to mount the at least  
one rotor position sensor in space-saving fashion on the motor  
region of the circuit board configuration, and to arrange  
other components in a component region outside the air duct,  
thus allowing the annular air flow cross section to be made

larger than previously. This permits larger fan blades to be used, and thus a greater flow rate and/or a greater pressure increase to be achieved for the same physical size.

Another manner of achieving the stated object is  
5 ~~evident from the subject matter of Claim 14.~~ to arrange a  
motor region, of the control circuit board, on an inner side  
of the air duct between the carrier hub and the claw-pole  
stator. The combination according to this claim results, even  
10 in micro-fans, in very favorable values for flow rate and  
pressure increase, which are increasingly in demand nowadays.  
A compact design with a large annular air flow cross section,  
and consequently a particularly large flow rate, is thus  
obtained, so that a configuration of this kind according to  
the invention represents a particularly advantageous  
15 combination for miniature fans and micro-fans.

These approaches to achieving the object of the present  
invention create the possibility of increasing the number of  
functions for a miniature fan or micro-fan. For example, when  
miniature fans or micro-fans are used in open- or closed-loop  
20 control systems or management systems, they must not generate  
any electromagnetic interference, i.e. their electromagnetic  
compatibility (EMC) must meet high standards; this requires  
more components and more-complex circuits, which the invention  
now makes possible for the first time in compact form for  
25 miniature fans and micro-fans as well.

With the invention, it is also possible to integrate into  
the circuitry of such a fan additional functions that are now  
increasingly in demand, e.g. PWM open- and closed-loop control  
systems, analog rotation speed controllers, digital rotation  
30 speed controllers, programmable rotation speed controllers,  
switching thresholds for analog control systems, etc. This  
also allows reliable control of a miniature fan or micro-fan  
via a data bus such as those now common, for example, in motor  
vehicles.

Further details and advantageous refinements of the invention are evident from the exemplary embodiments, in no way to be understood as a limitation of the invention, that are described below and illustrated in the drawings.  
5 ~~and from the dependent claims.~~

~~In the drawings:~~ BRIEF FIGURE DESCRIPTION:

FIG. 1 is a plan view of a double fan comprising two miniature fans or micro-fans, at very greatly enlarged scale;

FIG. 2 is an individual depiction of a circuit board used  
10 in the double fan of FIG. 1;

FIG. 3 shows a first embodiment of an individual miniature fan or micro-fan in which most of the electronic components are housed in a lateral housing part, the connection from the motor to the lateral components being  
15 accomplished via a flexible conductor;

FIG. 4 shows a second embodiment of a miniature fan, viewed in the direction of arrow IV of FIG. 5, in which most of the electronic components are housed in a lateral housing part, the connection from the motor to the lateral components  
20 being accomplished via a rigid conductor;

FIG. 5 is a section viewed along line V-V of FIG. 4;

FIG. 6 shows a third embodiment of a miniature fan, viewed in the direction of arrow VI of FIG. 7, in which most of the electronic components are housed in a narrow lateral  
25 housing part and the connection from the motor to the lateral components is accomplished via flexible stranded conductors;

FIG. 7 is a section viewed along line VII-VII of FIG. 6;  
and

FIG. 8 depicts a micro-fan according to the present  
30 invention at approximately actual size.

DETAILED DESCRIPTION:

FIG. 1 shows, at greatly enlarged scale, a double fan 20 comprising a housing 22 in which two miniature fans or micro-fans 24, 26, each driven by an electronically commutated external-rotor motor 28, 30, are arranged next to one another. These motors 28, 30 are rigidly connected to housing 22 by way of struts (not depicted).

According to the invention and as shown in FIG. 2, a circuit board 32 that has, for motor 28, a first approximately annular part 34, on which a Hall IC 36 and four attachment points 38 for the winding ends of motor 28 are provided, is used in the double fan of FIG. 1. Part 34 is connected, via a first bridge 40 comprising printed conductors (not depicted), to a second approximately annular part 42 on which are located a Hall IC 44 and four attachment points 46 for the winding ends (not depicted) of motor 30.

Part 42 is connected, via a second bridge 48 comprising printed conductors (not depicted), to an (in this case, rectangular) part 50 on which most of the electronic components of the two motors 28, 30 are arranged. The connection to motors 28, 30 is accomplished via printed conductors (not depicted) on parts 34, 40, 42, 48, and 50.

Bridges 40, 48 are preferably arranged in such a way that they each extend under a strut that respectively connects motor 28, 30 to housing 22. For that purpose they can also, as applicable, extend obliquely.

FIG. 3 depicts an analogous arrangement 60 comprising a single miniature fan 62, implemented as an axial fan, that is shown greatly enlarged. This fan has a hub 64 that is connected via struts 66 to a housing 68. Mounted on this hub 64 is an external-rotor motor 70 that has an internal stator 72 having claw poles 74 and an annular winding 76. Rotating around internal stator 72 is an external rotor 80 having a rotor cup 82 made of plastic, into which is injection-embedded a magnetic yoke ring 84 on which is arranged an annular permanent magnet 86 that is radially magnetized. The blades of

fan 62 are labeled 106, and are mounted on rotor cup 82. Located between internal stator 72 and hub 64 is a circuit board 90, connected to which electrically and mechanically is a flexible conductor 92 that leads to a circuit board 94 and is electrically and mechanically connected thereto. Most of the electronic components 96 of motor 70 are located on circuit board 94, with the exception of a Hall IC (not depicted) that is arranged on circuit board 90 in the region of the magnetic field of rotor 86, and is controlled by that magnetic field.

Circuit board 94 with its components 96 is located in a lateral housing part 98 that, after assembly, is sealed by a cover 100 on which circuit board 94 is secured by means of support members 102.

It is advantageous here that with this arrangement, cover 100 can be swung down to the right for assembly; and that after assembly, it can be connected in liquid-tight fashion to part 98. Flexible conductor 92 thus enables problem-free assembly.

FIGS. 4 and 5 show a miniature fan 110 comprising an approximately rectangular housing 112 that has an air duct 114 in which hub 118 of an external-rotor motor 120 is held by struts 116. As in FIG. 3, motor 120 has an internal stator 122 with claw poles 124 and an annular winding 126. An external rotor 128, on which five fan blades 130 of an axial fan are provided, rotates about internal stator 122.

A rigid circuit board 134, whose shape is indicated with dashed lines in FIG. 4, extends between hub 118 and internal stator 122. Circuit board 134 is approximately annular in the region between hub 118 and internal stator 122, and it carries there a Hall IC (not depicted) as well as connecting points for the attachment of annular winding 126. The reader is referred to the analogous depiction in FIG. 2.

From the annular portion of circuit board 134, a narrow bridge 136 goes to a larger, approximately rectangular part 138 on which the essential electronic components 140 of motor

120 are arranged (see FIG. 5). This part 138 is located in a space 144 that can be sealed by a cover 142.

As is directly apparent, circuit board 134 populated with components 140 can be very easily installed before cover 142 is put in place.

Housing 112 is equipped with four openings 148 for mounting it.

FIGS. 6 and 7 show, once again greatly enlarged, a miniature fan or micro-fan comprising a housing 150 in which is provided an air duct 152 in which hub 156 of a claw-pole external-rotor motor 158, whose external rotor 160 carries five blades 162, is mounted by means of struts 154.

Located between hub 156 and motor 158 is an annular circuit board 163 that, similarly to FIG. 2, carries a Hall IC (not depicted) and attachment points for stator winding 164 of motor 158.

Also provided, to the side of air duct 152, is a housing part 166 in which a circuit board 168 having electronic components 170 of motor 158 is mounted. Housing part 166 is closed after assembly by a cover 172.

The connection from circuit board 163 to circuit board 168 is accomplished here by means of flexible electrical conductors 174, called stranded conductors, that are permanently soldered onto the two circuit boards 163 and 168. Stranded conductors of this kind can be mounted particularly easily on a strut 154 of fan housing 150.

FIG. 8 shows a micro-fan 200 according to the invention. A one-centimeter length is indicated at the left as a scale; in other words, fan 200 is shown slightly enlarged. It has external dimensions of 35 x 40 x 8 mm, and a weight of approx. 5 g. Five fan blades 204 are arranged externally on its motor 202. The motor has a power consumption of 0.5 W and a rated rotation speed of 9000 rpm. Viewed as depicted in FIG. 8, fan 200 runs counterclockwise and blows toward the back.

Housing 150 of fan 200 has, on the right side as depicted, an enlargement in which circuit board 168 with (schematically indicated) electronic components 170 is located (see FIG. 7). The lateral enlargement is closed by cover 172, but in some cases can also be open. The connection from circuit board 168 to motor 202 is preferably accomplished in the manner depicted, in greatly enlarged fashion, in FIGS. 6 and 7.

Because components 170 are not arranged directly inside motor 202 but instead in the lateral enlargement of housing 150, the diameter of motor 202 can be correspondingly reduced, e.g. from 17.5 to 13.5 mm. With only slightly greater dimensions for housing 150, the flow rate  $V/t$  of fan 200 for a given static pressure  $\Delta p_f$  thus rises approximately 80 to 110%, e.g. from 1.5 m<sup>3</sup>/h to 3.2 m<sup>3</sup>/h. The invention thus allows an improved flow rate, and consequently better cooling performance, to be obtained in such micro-fans with very simple means.

Aspects common to all the approaches depicted are that they greatly simplify, even for very small fans, assembly of the electronics for the fan's electronically commutated drive motor; that the volume and weight of the fan are not substantially increased; and that they enable new fan electronics functions for miniature fans and micro-fans of this kind.

Lateral installation of the motor electronics further allows the size of the motor hub to be reduced, i.e. the cross section for air passage, and therefore the fan performance and pressure increase of the fan, can be very easily increased by means of the invention.

Many variants and modifications are of course possible within the scope of the present invention.



CLAIMS WHAT IS CLAIMED IS:

1. (Presently amended) A miniature fan or micro-fan which comprises a fan housing (22; 68; 112; 150) through which a substantially annular air duct (114; 152) extends in the axial direction,

there being arranged in a central region of the air duct (114; 152) a carrier hub (64; 118; 156) which carries the internal stator (72; 122) of an electronically commutated external-rotor motor (28, 30; 70; 158; 202) whose external rotor (80; 160), equipped with at least one permanent magnet (86), carries an impeller wheel (130; 162) that is arranged rotatably in the air duct (114),

and comprising a circuit board configuration (32; 90, 94; 134; 163)

- which comprises a motor region (34; 42) that is arranged in the central region of the air duct between the carrier hub (64; 118) and the internal stator (122), and carries at least one galvanomagnetic rotor position sensor (36; 44) that is controllable by the magnetic field of the permanent magnet (86) provided on the external rotor,

- which comprises a component region (50; 138) for the reception of electronic components (96; 170) of the external-rotor motor, which component region is arranged on said fan housing (22; 68) substantially outside the air duct (114; 152); and

- which comprises a bridge portion (40; 48; 136; 174) by way of which the motor region (163) of the circuit board configuration is electrically connected to the component region (168), said bridge portion extending from said motor region through the annular air duct (114; 152) to said component region (50; 138).

2. (Original) The fan according to claim 1, wherein the motor region, bridge portion, and component region are implemented as parts of the same circuit board.

3. (Presently Amended) The fan according to claim 1 ~~or 2~~, wherein the circuit board is implemented at least locally in flexible fashion.

4. (Original) The fan according to claim 3, wherein the flexible region is deflected between the motor region and component region.

5. (Presently Amended) The fan according to ~~any of the preceding claims~~ claim 1, wherein the circuit board configuration comprises flexible stranded conductors in the bridge region between the motor region and component region.

6. (Presently Amended) The fan according to ~~any of the preceding claims~~ claim 1, which is implemented as an axial fan.

7. (Presently Amended) The fan according to ~~any of the preceding claims~~ claim 1, wherein the internal stator is implemented with claw poles (74; 124) and an annular winding (76; 126; 164).

8. (Original) The fan according to claim 7, wherein the annular winding (76; 126; 164) is electrically connected to the motor region of the circuit board configuration.

9. (Presently Amended) The fan according to ~~any of the preceding claims~~ claim 1, wherein the component region (138; 168) is arranged substantially in a closed-off region (98; 142; 172) of the fan housing (22; 68).

10. (Presently Amended) The fan according to claim 9, wherein the closed-off region is sealed, ~~preferably~~ in liquid-tight fashion, by means of a cover (100; 172).

11. (Original) The fan according to claim 10, wherein the component region (94) of the circuit board configuration is mounted on the cover (100) by means of at least one support member (102).

12. (Presently Amended) The fan according to ~~any of the preceding claims~~ claim 1, which is controllable via a data bus.

13. (Presently Amended) The fan according to ~~any of the preceding claims~~ claim 1, wherein a bridge portion (40, 48; 136) of the circuit board configuration (32; 90, 94; 134; 163) extends in the region of a strut, the latter connecting the external-rotor motor (28, 30) to the fan housing (22).

14. (Presently Amended) A miniature fan or micro-fan which comprises a fan housing (22; 68; 112; 150) through which a substantially annular air duct (114; 152) extends in the axial direction, that housing being connected via at least one carrier member to a carrier hub (64; 118; 156)

that is arranged in a central region of the air duct (114; 152) and carries the internal stator (72; 122), comprising an annular winding (76; 126; 164) and implemented as a claw-pole stator, of an electronically commutated external-rotor motor (28, 30; 70; 158) whose external rotor (80; 160), equipped with at least one permanent magnet (86), carries fan blades (130; 162) that are arranged in the air duct (114),

and comprising a circuit board configuration (32; 90, 94; 134; 163)

- which comprises a motor region (34; 42) that is arranged on the radially inner side of the air duct between the carrier hub (64; 118) and the claw-pole stator (122), is adapted for electrical connection to the annular winding (76; 126; 164) of the claw-pole stator, and carries at least one galvanomagnetic rotor position sensor (36; 44) that is controllable by the magnetic field of the at least one permanent magnet (86) provided on the external rotor,

- which comprises a component region (50; 138) for the reception of electronic components (96) of the external-rotor motor, which component region is arranged substantially outside the air duct; and

- which comprises a bridge portion (40; 48; 136; 174) by way of which the motor region (163) of the circuit board configuration is electrically connected to the component region (168), said bridge portion extending from said motor region (163) through the annular air duct (114; 152) to said component region (168) of the circuit board.

15. (Original) The fan according to claim 14, which is implemented as an axial fan.

16. (Presently Amended) The fan according to claim 14 ~~or 15~~,

wherein the component region (138; 168) is arranged substantially in a closed-off region (98; 142; 172) of the fan housing (22; 68).

17. (Presently Amended) The fan according to claim 16, wherein the closed-off region is sealed, ~~preferably~~ in liquid-tight fashion, by a cover (100; 172).

18. (Original) The fan according to claim 17,  
wherein the component region (94) of the circuit board  
configuration is mounted on the cover (100) by means of  
at least one support member (102).

19. (Presently Amended) The fan according to  
~~any of claims 14 through 18~~ claim 14,  
which is controllable via a data bus.

20. (New) The fan according to claim 1, wherein the  
circuit board extends in a component region (138; 168)  
in a direction running substantially parallel to  
a direction of said air duct (114; 152).

21. (New) The fan according to claim 14, wherein the  
circuit board extends in a component region (138; 168)  
in a direction running substantially parallel to  
a direction of said air duct (114; 152).

# ABSTRACT

~~The invention concerns a~~ A miniature fan or micro-fan (200) ~~which comprises features~~ a fan housing (150) through which a substantially annular air duct extends in the axial direction, there being arranged in a central region of the air duct an electronically commutated external-rotor motor (202) whose external rotor, equipped with at least one permanent magnet (86), carries an impeller wheel (204) that is arranged rotatably in the air duct, ~~and comprising a~~ A circuit board configuration (168) ~~which comprises~~ has a motor region that is arranged in the central region of the air duct and carries at least one galvanomagnetic rotor position sensor that is controllable by the magnetic field of the permanent magnet (86) provided on the external rotor, ~~which comprises~~ The board has a component region for the reception of electronic components (170) of the external-rotor motor, which component region is arranged substantially outside the air duct, and which comprises a bridge portion, via which the motor region of the circuit board configuration is electrically connected to the component region (168).